T H E S I S

Submitted for the DEGREE of DOCTOR of PHILOSOPHY

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on

THE COMPOSITION OF MARE'S MILK.

by

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INTRODUCTORY.

The composition of the milk of the cow has naturally attracted much attention because of its importance as a human food. A knowledge of the chemistry of the milk of other domestic animals is, however, unfortunately defective, notwithstanding the fact that normal milk is an essential factor in the satisfactory rearing of the young.

While, to a large extent, the selection and breeding of cows have been controlled by a desire to improve either the quality or quantity or both of the milk, no such consideration has hitherto influenced breeders of horses. The suitability of the milk of mares for the rearing of healthy foals has seemingly been taken for granted.

Not infrequently complaints are made that a suckling animal is unable to rear her offspring satisfactorily, and this is the case occasionally with brood mares. Samples of mare's milk in cases of this nature having been received in the laboratory for examination, search of the literature for information/

information on the normal composition naturally followed. While no information seems to be available regarding the malnutrition of foals that result from the secretion of abnormal milk by the dam, several publications deal with the normal composition of mare's milk, though some of them are reports of analyses made before modern improvements in technique were adopted. Almost all work published hitherto deals with the milk of German, French or Russian mares; and to a certain extent this is understandable in view of the utilisation of mare's-milk-koumiss for human consumption. Nevertheless it seems strange that the economic importance of British horses has not hitherto led to a detailed examination of the milk of the mares of our own breeds.

The importance of a clear conception of the composition of mare's milk may be emphasised by the mention of the well-known difficulty in rearing orphan foals satisfactorily on substitutes, a difficulty that is probably greater than that with the young of any other domestic animal.

For purposes of comparison, the recorded work of previous investigators may be grouped conveniently in the form of a table.(TABLE I).

TABLE I.

THE PERCENTAGE COMPOSITION OF MARE'S MILK AS STATED BY PREVIOUS OBSERVERS.

	TOTAL SOLIDS %	PROTEIN %	FAT %	SUGAR %	ASH %
SCHRODT (1)	8.85	1.50	1.27	5.75	.37
BECQUEREL & VERNOIS (2)	9.57	3.34	2.44	3.28	.52
FLEISCHMANN (3)					
Average	9.30	2.00	1.20	5.70	.40
Maximum	10.95	3.00	2.45	7.26	1.20
Minimum	7.47	1.33	0.12	4.20	.28
KÖNIG (4)	9.42	2.05	1.14	5.87	.36
KÖNIG (5)					
(recent investigation)	10.12	2.20	0.54	6.97	.41
MOSER & SOXHLET (6)	7.51	1.69	0.65	4.72	.29
PETERSON & HOFKER (7)					
Average	9.82	2.14	0.61	6.73	.35
Maximum	10.43	2.63	1.07	7.12	.48
Minimum	9.40	1.56	0.37	6.34	.27
VIETH (8)					
Mixed milk of 15 mares					
Average	9.94	1.89	1.09	6.65	.31
Maximum	10.26	2.11	1.44	6.82	.34
Minimum	9.59	1.71	0.87	6.30	.29
Milk of individual mares					
Average	9.87	1.65	0.94	6.98	.30
Maximum	10.12	1.83	1.18	7.21	.36
Minimum	9.54	1.50	0.62	6.80	.26
Milk of two mares specially fed	10.78	1.99	1.48	7.03	.28
MONVOISIN (9)	10.80	2.30	2.00	5.60	.40
HILDEBRAND (10)	9.98	2.87	0.98	6.37	.45
WYNTER BLYTH (11)	11.20	2.70	2.50	5.50	.50

Average*	9.78	2.18	1.29	5.93	.38
Maximum	11.20	3.34	2.50	7.26	1.20
Minimum	7.47	1.33	0.12	3.28	0.26

* It is recognised that as the number and particulars of the analyses made by some of these workers is not known, the "average" figures here computed are not true averages but really represent the mean of the averages previously obtained.

These foregoing records of analyses have been collected from the literature and, so far as can be ascertained, comprise all former observations. In addition to the above, there was published in the Medical Press and Circular of 1869 (12) the statement that mare's milk contains total solids, 9.96%; protein, 3.84%; fat, 5.58%; sugar, 3.28%; and ash, .52% which, however, especially in the amount of fat, differs so widely from those determined at a later date that it cannot be regarded as being representative of normal mare's milk, and for this reason it is not included in the foregoing table.

In standard text-books on animal nutrition the composition of mare's milk most frequently given is:- (13) (14) total solids, 9.42%; protein, 2.05%; fat, 1.14%; sugar, 5.87%; and ash, .36%, and this, it will be seen, is remarkably close to the average figures here computed from previously recorded analyses.

Of the records given in TABLE I two are of particular interest. VIETH'S investigation attracts special attention because the samples analysed were obtained from mares that were accustomed to being hand-milked, being kept for the purpose of providing milk for making koumis. A stud of Tartary horses including 15 mares was brought from/

from the Russian Steppes in 1884 and exhibited at the International Health Exhibition for the purpose of advertising koumis and condensed mare's milk. The mares were from five to six years old and had foaled about five months previously. In view of the great difficulty in obtaining samples of mare's milk representative of twenty-four-hours secretion - a difficulty that does not exist with the cow - the procedure followed with these mares is of interest. From eight oclock in the morning to six o'clock in the afternoon the foals were kept from their dams, which were hand-milked every hour during this period. Thus VIETH was able to obtain representative samples and avoid the risk of analysing milk that had been retained in the udder under pressure with consequent fat depression.

VIETH found remarkably little variation in the milk of the fifteen mares; a uniformity in composition that may be accounted for by the frequency and regularity with which the milk cisterns were emptied, and also probably in part by the fact that the mares were selected, were of one breed and were fed and managed in an identical and uniform manner.

Search of the literature has brought to light/

light only one record of the analysis of British mare's milk. The late A. WYNTER BLYTH in his well-known text-book (11) gave the chemical composition of mare's milk that is quoted in TABLE I. His son, MR. M. WYNTER BLYTH, has informed me that the figures were obtained by analysis of milk of mares in North Devon (Barnstaple). The results are of special interest because Wynter Blyth found an appreciably higher percentage of total ash than is recorded for the average of the Continental mares to which reference has previously been made. His ash estimation agrees with those obtained in the present investigation for heavy breeds of horses. This will be further discussed when the mineral composition of milk is considered in detail.

THE/

THE PRESENT INVESTIGATION.

During the foaling season of 1926-7 samples of mare's milk were sent to my laboratory with requests for reports on their composition, it being suspected that the dams' milk did not agree with the foals. A considerable amount of variation having been found in these early samples more were collected and analysed at my request by my colleague, Prof. R.G. Thin, B.Sc., F.I.C. These are referred to in this paper as A1 to A25.

Because, other than that recorded by WYNTER BLYTH, no analyses of the milk of British breeds of horses could be found with which to compare the results obtained, it was decided to extend the investigation; and for this purpose requests for milk from mares were published in the Veterinary and Agricultural Journals during the two following foaling seasons. As a result a total of one hundred and forty-two samples were obtained and analysed, the composition of which forms the basis of the discussion in this Thesis.

The work undertaken was confined to the determination of the total solids, protein, fat, sugar and ash.

The/

The aims of the investigation were as follows:-

(a) To ascertain if the average composition of the milk of British mares is similar to that of Continental mares.

(b) To determine what differences, if any, exist.

(c) To ascertain if the composition of the milk of British mares is the same for each breed.

(d) In cases where the mares were suckling unthrifty foals, to attempt to ascertain if the composition of the milk could be held accountable for the failure of the foals to thrive.

Since numerous samples of colostrum were also received observations on their composition are noted.

Furthermore, during the investigation two samples of "Witches" milk (Hexenmilch) from foals born with fully functioning udders were received, and the opportunity is now seized to record their composition.

TECHNIQUE.

The technique used was the same as that employed by my colleague, Prof. Thin, B.Sc., F.I.C., who made the initial analyses (Nos. A1 to A25).

PROTEIN/

PROTEIN.

The total protein was estimated by KJELDAHL'S method, the nitrogen being multiplied by 6.33. Estimations were made in duplicate, 10 cc. of milk being used in each estimation.

TOTAL SOLIDS.

10 c.c. of milk was evaporated to dryness and kept in a water oven until constant weight had been reached.

ASH.

The dried residual solids, after having been burnt off in open air over a low Bunsen flame, were ashed in a muffle furnace, the back of the furnace just showing a dull red heat.

FAT.

The estimations recorded were obtained by the WERNER-SCHMID method. 10 c.c. of milk was placed in a test tube of 90 c.c. capacity together with an equal quantity of concentrated hydrochloric acid. The mixture was then heated in a water-bath with frequent shaking until the fluid had turned dark brown. After cooling it was run into a 50 c.c. burette and ether was added nearly to fill the tube, the/

the end of which was then closed with a cork. The contents were mixed by gently elevating each end of the tube alternately 30 times. The burette was then clamped vertically and the ether given time to rise above the brown fluid that was then run into the test tube together with about 10 c.c. of the ether. The bulk of the ether, in which was held in solution the fat abstracted from the fluid, was run into a separating funnel containing about 30 c.c. of water. The brown fluid plus the 10 c.c. of ether was returned to the burette which was then filled with fresh ether and the contents mixed carefully by tilting the tube alternately from end to end 20 times. After the ether had been allowed to rise as before, the brown fluid was run off and discarded and the ether added to that in the separating funnel. The burette was washed out with fresh ether which was added to the rest. The ether was well shaken up with the water in the separating funnel and allowed to rise and when the water was run off, the ether containing the fat was discharged into a weighed fat flask containing a few porcelain chips, and then distilled. The fat left in the flask was kept at 100°C. until constant weight had been reached, the percentage of fat being then estimated.

In/

In nearly all cases check tests were made by the GERBER centrifuge method, which usually gave readings 0.1 per cent lower than the estimation by the WERNER-SCHMID method.

For accurate results, the WERNER-SCHMID method was found to require great care in manipulation and check tests proved useful, particularly since in the course of the investigation some abnormal fat contents were found.

SUGAR.

It being found impracticable to estimate the sugar directly in anything but a very small proportion of the samples, the sugar percentages given in the tables are determinations "by difference". When routine work permitted, the sugar was estimated gravimetrically as cupric oxide in a Gooch crucible over asbestos wool. These estimations served as occasional checks on the accuracy of the other observations.

RESULTS./

TABLE II.

THE COMPARISON OF 104 SAMPLES OF MILK (NON-COLOSTRAL) FROM VARIOUS BREEDS.

NO.	BREED	AGE	DAYS AFTER FOALING	TOTAL SOLIDS	PROTEIN	FAT	SUGAR	ASH
3	S	7	20 days	9.74	1.92	.38	6.80	.64
4	C	10	5 "	11.11	3.88	.31	6.17	.75
7	L.D.	?	12 "	13.01	2.03	3.49	6.96	.53
8	C	?	9 "	8.97	2.94	1.40	3.93	.70
9	C	?	10 "	18.74	7.60	7.88	2.31	.95
10	C	7	20 "	10.39	2.41	.42	7.02	.54
11	H	9	10 "	12.84	1.52	3.40	7.11	.81
12	C	?	9 "	12.41	3.01	2.23	6.69	.48
14	C	6	8 "	10.01	2.29	.42	6.81	.49
15	C	5	40 "	13.23	2.85	3.50	6.33	.55
17	?	?	28 "	9.98	1.94	1.05	6.53	.46
18	C	8	11 "	10.12	2.20	.45	6.93	.54
19	C	12	10 "	11.47	2.80	1.68	6.42	.57
20	T	18	48 "	12.26	2.42	3.35	6.09	.40
21	T	8	58 "	10.96	2.09	2.06	6.36	.45
24	T	8	82 "	10.01	2.08	.59	6.97	.37
25	C	8	7 "	10.72	2.73	1.68	5.71	.60
26	S	?	30 "	10.90	2.19	1.47	6.69	.55
27	C	20	35 "	11.68	2.26	1.99	7.01	.42
28	C	8	13 "	11.03	2.52	1.13	6.88	.50
29	T	10	35 "	9.26	1.99	.25	6.73	.29
32	C	7	30 "	8.80	2.83	1.19	4.24	.54
33	C	?	17 "	10.21	2.46	.39	6.96	.40
34	C	?	18 "	12.39	2.80	.94	8.17	.48
35	C	?	43 "	11.79	2.59	2.21	6.49	.50
36	C	?	24 "	10.93	2.04	1.71	6.77	.41
38	C	?	42 "	10.61	2.66	.45	7.05	.45
39	C	?	47 "	10.67	2.31	.44	7.48	.44
40	C	?	19 "	12.42	3.38	2.49	5.99	.56
41	T	?	100 "	10.34	.55	.73	8.78	.28
42	C	7	23 "	11.40	2.89	1.81	6.18	.52
43	S	6	19 "	10.55	2.47	.09	7.50	.49
44	S	?	13 "	10.44	2.08	.57	7.26	.53
45	C	14	6 "	11.43	3.23	.67	6.99	.54
48	C	13	8 "	12.97	2.76	2.28	7.37	.56
49	?	7	56 "	11.15	2.41	1.77	6.52	.45
50	C	7	56 "	11.58	3.28	1.51	6.25	.54

TABLE II. Contd.

THE COMPARISON OF 104 SAMPLES OF MILK (NON-COLOSTRAL) FROM VARIOUS BREEDS.

NO.	BREED	AGE	DAYS AFTER FOALING	TOTAL SOLIDS	PRO-TEIN	FAT	SUGAR	ASH
51	F.P.	?	63days	10.46	2.28	.66	7.08	.44
52	S	6	35 "	9.36	2.41	.20	6.27	.48
55	T	19	Weaning	8.64	2.08	.35	5.78	.43
59	?	?	270 "	5.93	1.65	.77	3.13	.48
60	T	9	90 "	9.61	1.71	.33	7.26	.31
63	T	?	34 "	11.64	2.09	2.70	6.42	.43
66	C	5	6 "	11.09	2.68	1.44	6.30	.67
69	C	5	5 "	11.59	2.60	2.10	6.26	.63
71	C	5	4 "	10.95	2.90	1.72	5.73	.60
74	C	5	7 "	9.97	2.72	.13	6.57	.55
76	T	?	7 "	9.71	3.48	1.71	3.82	.70
77	S	9	270 "	13.49	5.44	2.57	4.87	.51
81	C	7	14 "	11.24	2.41	1.95	6.23	.65
83	C	?	7 "	11.71	2.91	2.25	6.02	.53
84	T	?	? "	11.22	2.53	.29	7.85	.55
85	L.D.	13	35 "	10.83	2.65	1.58	6.01	.59
86	?	?	? "	11.49	2.28	2.40	6.34	.47
87	S.P.	6	14 "	10.30	2.48	.90	6.65	.35
88	C	?	9 "	8.14	3.04	1.36	3.06	.68
89	S.P.	6	14 "	9.62	1.90	.50	6.91	.31
92	C	13	10 "	13.02	4.62	2.32	5.44	.64
93	P	16	21 "	10.77	2.53	2.40	5.42	.42
95	C	Aged	8 "	11.81	3.10	2.21	5.88	.62
96	C	?	7 "	11.92	3.04	2.00	6.33	.55
97	C	6	21 "	9.02	1.71	.26	6.62	.43
98	T	18	30 "	12.05	1.52	1.82	8.29	.42
100	S	?	4 "	10.83	3.57	.65	5.89	.72
101	C	5	14 "	10.19	2.84	.40	6.42	.53
102	C	10	13 "	11.26	2.60	1.89	6.27	.50
103	S	4	28 "	11.87	3.86	2.20	5.40	.41
107	C	4	30 "	10.85	2.65	1.25	6.49	.46
109	C	?	8 "	10.27	2.72	1.30	5.71	.54
110	C	7	27 "	10.74	2.60	1.70	5.95	.49
112	T	?	90 "	10.97	1.96	.57	8.07	.37
113	C	7	6 "	12.13	3.17	1.70	6.65	.61
115	C	?	30 "	10.11	3.10	1.80	4.78	.43
116	C	?	75 "	10.38	2.34	1.30	6.45	.29

TABLE II. Contd.

THE COMPARISON OF 104 SAMPLES OF MILK (NON-COLOSTRAL) FROM VARIOUS BREEDS.

NO.	BREED	AGE	DAYS AFTER FOALING	TOTAL SOLIDS	PRO-TEIN	FAT	SUGAR	ASH
117	C	?	45days	9.93	2.46	54	6.45	.48
119	T	?	105 "	10.59	1.93	1.24	7.14	.28
120	C	5	9 "	12.81	3.61	2.00	6.66	.54
121	T	?	90 "	10.40	1.90	1.14	7.03	.33
122	?	3	21 "	9.88	2.41	.54	6.42	.51
123	T	9	60 "	10.73	2.41	1.10	6.80	.42
124	C	24	14 "	12.12	3.29	2.14	6.09	.60
125	C	9	120 "	9.16	2.15	.28	6.45	.28
A 1	C	7	60 "	12.58	3.35	2.65	6.08	.50
A 2	C	?	42 "	10.42	3.04	.75	6.06	.57
A 3	C	?	7 "	8.77	2.28	.85	5.06	.58
A 4	C	?	13 "	9.39	2.02	2.75	4.01	.61
A 5	C	?	14 "	11.09	2.53	1.50	6.59	.47
A 6	C	?	12 "	9.80	2.47	1.52	5.19	.62
A 7	C	?	14 "	11.40	2.47	2.60	5.84	.49
A 9	H	Aged	21 "	13.93	3.23	4.40	5.86	.44
A10	?	?	16 "	12.42	3.23	5.30	3.15	.74
A11	C	?	31 "	9.87	2.47	.70	6.17	.53
A12	C	?	40 "	10.09	2.22	.75	6.64	.48
A13	C	?	? "	13.03	3.17	3.60	5.79	.47
A14	C	?	35 "	10.53	2.47	1.85	5.60	.61
A15	C	14	10 "	8.95	2.91	.40	5.19	.45
A16	C	?	? "	11.41	3.79	1.30	5.70	.62
A17	C	?	? "	12.55	2.53	3.30	6.34	.38
A18	C	?	? "	10.67	2.59	2.00	5.68	.40
A19	C	?	? "	11.42	3.61	1.70	5.49	.62
A22	C	?	7 "	10.96	3.48	1.09	4.80	.59
A23	H	?	75 "	11.43	2.60	2.25	6.15	.43
A24	H	?	30 "	8.70	3.42	2.85	1.65	.75
A25	?	?	? "	12.58	3.35	2.65	6.08	.50
		Average		10.96	2.69	1.59	6.14	.51
		Maximum		18.74	7.60	7.88	8.78	.95
		Minimum		5.93	0.55	0.09	1.65	.28

C, Clydesdale.
S, Shire,
H, Hunter.
T, Thoroughbred.

L.D., Light Draught.
P, Pony.
S.P., Shetland Pony.
F.P., Fell Pony.

RESULTS.

Of the samples supplied from one hundred and forty-two mares of different breeds, thirty-eight were collected during the first three days after parturition. There were therefore one hundred and four from which to establish the average composition of the milk of British mares, and thirty-eight from which to observe the composition of colostrum. The results obtained by analysis, together with the breed and age of the mare (when known) and the number of days that had elapsed after foaling before the sample of milk was collected, are collated in **TABLE II.**

For the purpose of determining the occurrence of any difference in the composition of the milk of different breeds, the results of analyses have been brought together and placed under their respective headings. The representatives of each breed are as follows:- 62 Clydesdales, 8 Shires, 14 Thoroughbreds, 4 Ponies and 1 Hunter.

It is unfortunate that among the 104 results of analyses given in TABLE II many are of samples/

samples obtained from mares the breed of which was not stated. While this necessarily lessens the reliability of the comparisons between different breeds, the residual facts are of moment, and indicated herewith.

CLYDESDALE (62 MARES).

NO.	SOLIDS	PROTEIN	FAT	SUGAR	ASH
	%	%	%	%	%
4	11.11	3.88	.31	6.17	.75
8	8.97	2.94	1.40	3.93	.70
10	10.39	2.41	.42	7.02	.54
12	12.41	3.01	2.23	6.69	.48
14	10.01	2.29	.42	6.81	.49
15	13.23	2.85	3.50	6.33	.55
18	10.12	2.20	.45	6.93	.54
19	11.47	2.80	1.68	6.42	.57
25	10.72	2.73	1.68	5.71	.60
27	11.68	2.26	1.99	7.01	.42
28	11.03	2.52	1.13	6.88	.50
32	8.80	2.83	1.19	4.24	.54
33	10.21	2.46	.39	6.96	.40
34	12.39	2.80	.94	8.17	.48
35	11.79	2.59	2.21	6.49	.50
36	10.93	2.04	1.71	6.77	.41
38	10.61	2.66	.45	7.05	.45
39	10.67	2.31	.44	7.48	.44
40	12.42	3.38	2.49	5.99	.56
42	11.40	2.89	1.81	6.18	.52
45	11.43	3.23	.67	6.99	.54
48	12.97	2.76	2.28	7.37	.56
50	11.58	3.28	1.51	6.25	.54
66	11.09	2.68	1.44	6.30	.67
69	11.59	2.60	2.10	6.26	.63
71	10.95	2.90	1.72	5.73	.60
74	9.97	2.72	.13	6.57	.55
81	11.24	2.41	1.95	6.23	.65
83	11.71	2.91	2.25	6.02	.53
88	8.14	3.04	1.36	3.06	.68
92	13.02	4.62	2.32	5.44	.64
95	11.81	3.10	2.21	5.88	.62
96	11.92	3.04	2.00	6.33	.55
97	9.02	1.71	.26	6.62	.43

CLYDESDALE (62 MARES). Contd.

NO.	SOLIDS	PROTEIN	FAT	SUGAR	ASH
	%	%	%	%	%
101	10.19	2.84	.40	6.42	.53
102	11.26	2.60	1.89	6.27	.50
107	10.85	2.65	1.25	6.49	.46
109	10.27	2.72	1.30	5.71	.54
110	10.74	2.60	1.70	5.95	.59
113	12.13	3.17	1.70	6.65	.61
115	10.11	3.10	1.80	4.78	.43
116	10.38	2.34	1.30	6.45	.29
117	9.93	2.46	.54	6.45	.48
120	12.81	3.61	2.00	6.66	.54
124	12.12	3.29	2.14	6.09	.60
125	9.16	2.15	.28	6.45	.28
A 1	12.58	3.35	2.65	6.08	.50
A 2	10.42	3.04	.75	6.06	.57
A 3	8.77	2.28	.85	5.06	.58
A 4	9.39	2.02	2.75	4.01	.61
A 5	11.09	2.53	1.50	6.59	.47
A 6	9.80	2.47	1.52	5.19	.62
A 7	11.40	2.47	2.60	5.84	.49
A11	9.87	2.47	.70	6.17	.53
A12	10.09	2.22	.75	6.64	.48
A13	13.03	3.17	3.60	5.79	.47
A14	10.53	2.47	1.85	5.60	.61
A15	8.95	2.91	.40	5.19	.45
A16	11.41	3.79	1.30	5.70	.62
A17	12.55	2.53	3.30	6.34	.38
A18	10.67	2.59	2.00	5.68	.40
A19	11.42	3.61	1.70	5.49	.62
A22	10.96	3.48	1.09	5.80	.59
Average	10.91	2.78	1.46	6.13	.52
Maximum	13.03	4.62	3.60	8.17	.75
Minimum	8.14	1.71	.13	3.06	.28

SHIRE (8 MARES).

NUMBER	SOLIDS	PROTEIN	FAT	SUGAR	ASH
	%	%	%	%	%
3	9.74	1.92	.38	6.80	.64
26	10.90	2.19	1.47	6.69	.55
43	10.55	2.47	.09	7.50	.49
44	10.44	2.08	.57	7.26	.53
52	9.36	2.41	.20	6.27	.48
77	13.49	5.44	2.57	4.97	.51
100	10.83	3.57	.65	5.89	.72
103	11.87	3.86	2.20	5.40	.41
Average	10.90	2.99	1.02	6.34	.54
Maximum	13.49	5.44	2.57	7.50	.72
Minimum	9.36	1.92	.09	4.97	.41

THOROUGHBRED (14 MARES).

NUMBER	SOLIDS	PROTEIN	FAT	SUGAR	ASH
	%	%	%	%	%
20	12.26	2.42	3.35	6.09	.40
21	10.96	2.09	2.06	6.36	.45
24	10.01	2.08	.59	6.97	.37
29	9.26	1.99	.25	6.73	.29
41	10.34	.55	.73	8.78	.28
55	8.64	2.08	.35	5.78	.43
60	9.61	1.71	.33	7.26	.31
63	11.64	2.09	2.70	6.42	.43
84	11.22	2.53	.29	7.85	.55
98	12.05	1.52	1.82	8.29	.42
112	10.97	1.96	.57	8.07	.37
119	10.59	1.93	1.24	7.14	.28
121	10.40	1.90	1.14	7.03	.33
123	10.73	2.41	1.10	6.80	.42
Average	10.62	1.94	1.18	7.11	.38
Maximum	12.26	2.53	3.35	8.78	.55
Minimum	8.64	.55	.25	5.78	.28

PONIES.

Samples of milk were obtained from four ponies, a Fell pony, two Shetlands and one of which the breed was not stated.

NO.	SOLIDS	PROTEIN	FAT	SUGAR	ASH
	%	%	%	%	%
51	10.46	2.28	.66	7.08	.44
87	10.30	2.40	.90	6.65	.35
89	9.62	1.90	.50	6.91	.31
93	10.77	2.53	2.40	5.42	.42
Average	10.29	2.28	1.11	6.51	.38
Maximum	10.77	2.53	2.40	7.08	.44
Minimum	9.62	1.90	.50	5.42	.31

HUNTERS.

Several samples were sent from Hunter brood mares but only one, A23, could be regarded as normal milk, its composition being, solids, 11.43%; protein, 2.60%; fat, 2.25%; sugar, 6.15%; ash, .43%.

A comparison of the results obtained during the present investigation and the figures given by all previous observers may be made by an examination of the following TABLE, in which analyses have been reduced to average, maximum and minimum.

TABLE III.

PREVIOUS OBSERVATIONS.

TABLE I.	TOTAL SOLIDS.	PROTEIN.	FAT.	SUGAR.	ASH.
	%	%	%	%	%
Average	9.78	2.18	1.29	5.93	0.38
Maximum	11.20	3.34	2.50	7.26	1.20
Minimum	7.47	1.33	0.12	3.28	0.26
		PRESENT INVESTIGATION.			
TABLE II.					
Average	10.96	2.69	1.59	6.14	0.51
Maximum	18.74	7.60	7.88	8.78	0.95
Minimum	5.93	0.55	0.09	1.65	0.28

From/

From the above figures it is evident that the average composition of the milk of British mares differs very little from that of Continental mares.(1)

The averages for protein, fat and sugar agree very closely.

The total solids for British breeds are slightly higher, but the only important difference is in the amount of mineral matter, which, taking the average of all samples examined, is higher than that found in the milk of Continental mares.

No appreciable variation in the constituents of the milk are notable in different breeds, except in regard to the mineral matter. The milk of the heavier breeds was found to contain more ash than is present in the milk of the lighter breeds, and is consequently given detailed consideration herein.

MINERAL MATTER.

The average amount of ash in one hundred and four samples of milk, free from colostrum, from mares of different breeds was found to be 0.51 per cent. This is considerably greater than the 0.38 per cent which is the average of the Continental figures/

(1) A note concerning the computation of these "averages" is given at the foot of TABLE I on page 3b.

figures.

A comparison of the ash content of the milk of the different British breeds seems to indicate that the amount of mineral matter in mare's milk increases with the increase in weight of the breed, as the following table shows:-

TABLE IV.

PERCENTAGE OF MINERAL MATTER IN THE MILK OF BRITISH BREEDS.

BREED	AVERAGE WEIGHT.	Ash percentage. AVERAGE	MAXIMUM	MINIMUM
	lbs.			
Shire	2,000	.54	.72	.41
Clydesdale	2,000	.52	.75	.28
Hunter	1,000 to 1,340	.43	--	--
Thoroughbred		.38	.55	.28
Ponies. Shetlands	336	.38	.44	.31
Fell	800			

With the above average weights should be compared those of German horses, which will be found to be appreciably less than those of Shires and Clydesdales. The average weights of German breeds are/

are as follows:- (1)

	lbs.
Rhineland draught horse	1,760
Hannoverian draught horse	1,670
Anhalt draught mares	1,550
East Prussian heavy cart horse	1,540
Oldenburg horse	1,390
Holstein coach horse	1,320

The higher average figures for the ash found during this enquiry is therefore possibly due to the large size of Clydesdales and Shires.

In the only record of milk analysis of British mares (that by WYNTER BLYTH), the percentage of ash is given as .50, that is the same as the average for 104 samples of Colostrum-free milk analysed in the investigation.

In this connection, it is well to remember that BUNGE, PROESCHER and ABDERHALDEN (15) have drawn attention to the definite relationship that exists between the rate of growth of animals of different species and the amount of protein and mineral matter in the milk, the rate of growth increasing with the increase in the amount of these constituents, as is shown in the accompanying TABLE.

TABLE/

(1) The weights of British and German horses were kindly obtained for me by the Imperial Bureau of Animal Genetics.

TABLE V.

SPECIES.	TIME REQUIRED TO DOUBLE WT. DAYS.	PROTEIN IN MILK PER CT.	TOTAL ASH IN MILK PER CT.
Human	180	1.6	0.20
Horse	60	2.0	0.40
Cow	47	3.5	0.70
Sheep	15	4.9	0.84
Pig *	14	5.2	0.80
Dog	9	7.4	1.33
Rabbit	6	14.4	2.50

* As HENRY and MORRISON (16) have pointed out, the modern pig may double its weight in from 9 to 10 days.

Now there are probably variations in the ash percentage in the milk of different breeds within a species; and if the growth rate of the individual member of a species is constant, notwithstanding variations in size and weight between breeds, then it might be expected that the breed with the greater average weight would have the higher percentage of ash, and vice versa. But information on this aspect of nutrition during the early period of extra-uterine life is very meagre and unsatisfactory. DROOP RICHMOND (17) quotes the following figures, obtained at/

at the New Jersey State Agricultural Experiment Station, for the percentage of ash of certain breeds of cows. To this has been added the average weight of each breed.

TABLE VI.

PERCENTAGE OF ASH IN THE MILK OF DIFFERENT BREEDS OF CATTLE.

BREED.	AVERAGE WEIGHT	ASH.
	lbs.	per cent.
Ayrshire	1051	0.69.
Guernsey	1000	0.75
Holstein	1250	0.64
Jersey	800	0.75
Shorthorn	1350	0.73

It is somewhat doubtful, however, if these figures have any significance or if they are applicable to cattle reared on British soil.

ABNORMAL/

ABNORMAL MILK.

While this investigation was primarily undertaken for the purpose of determining the normal composition of the milk of British mares reared and pastured on British soil, many samples of milk from mares whose foals were not thriving were sent for examination, and it is of interest to examine the records of these cases to see what bearing, if any, the composition of the milk had on the health and general vitality of the foal.

A condition of unthriftiness in sucking offspring may be due to one or more of several causes. For example, the young animal may be born with an inherent weakness or be suffering from a specific disease, such as "Joint Ill"; or, on the other hand, the maternal nutriment may be faulty either in quantity or in quality. It is in connection with the second of these conditions - the quality of the milk - that a study of the analyses may possibly throw some light on the inability, temporary or persistent, of the foal to thrive.

THE EFFECT OF OESTRUM.

It is well known that in those animals having an oestral period during lactation the milk may be changed to such an extent as to cause a definite disturbance in the young. Diarrhoea, which may last for several days, is a common symptom of the digestive disturbance that frequently follows the ingestion of the milk taken during this period, and it is well known that such milk may produce digestive troubles in children that drink it. (MONVOISIN)[18].

A great many observations have been made on the effect of oestrum on the milk of the cow and all observers agree that no general rule can be laid down as to the manner in which the milk may become changed at this period. (MACINTOSH[19], ERNST[20], MONVOISIN[18]). As ERNST expresses it "there are no set influences in one and the same animal, and still less so in different animals". The onset of oestrum may not affect the milk at all, but when it does there is usually a diminution in quantity and an increase in the amount of the total solids (FASCETTI and BERTOZZIE)[21]. ROLET[22] found an increase in dry matter and fat in the milk of one cow and the reverse in that of another. FASCETTI[23] gives analytical figures of the milk of a cow before, during/

during and after oestrum and shows that in this particular case oestrum produced a decided increase in total solids, protein, fat and ash, and a scarcely appreciable reduction in the amount of lactose. On the other hand a distinct diminution in the percentage of fat has been observed by DESCHAMBRE and GINIEIS (24).

The changes that take place in the composition of milk during oestrum are obviously very variable and appear to depend largely upon the degree of excitability of the animal. WEBER (25), for example, produced interesting evidence to show that the presence of a strange milker during the cow's oestrum intensifies the chemical changes. This, it would appear, has an important bearing upon the handling of mares, particularly those of an excitable nature, when in heat and indicates the advisability of keeping them as quiet as possible.

In addition to the facts disclosed by the observations just mentioned there can be no doubt that changes other than those in the amount of protein, fat, sugar and ash take place in the milk of some animals. In very excitable cows, for instance, oestral milk is decidedly acid and soon "turns", but whether a similar condition obtains in the milk of mares/

mares and sows has not yet been determined. A search of the literature has failed to find any reference to the condition and effects of mare's milk during oestrum.

OESTRAL MILK OF MARES.

During the present investigation it has fortunately been possible to extend our knowledge of the peculiarities of mare's oestral milk, for several samples have been received, and along with some of them was sent the statement that the foals were indisposed and suffering from diarrhoea. Owing to the fact that the milk was sent by post, in some cases from a considerable distance, it was decided that determinations of the reaction of samples would probably give misleading results, particularly so as mare's milk readily undergoes alcoholic fermentation. Although in some cases steps had been taken to preserve the milk by the use of formaldehyde, thymol, or ice packing, a slight acidity was almost inevitable.

The following table gives the analyses of those samples drawn during the oestral period that show some degree of departure from the normal. In addition/

addition other samples were obtained during the same period, but these presented no abnormality.

TABLE VII.

PERCENTAGE COMPOSITION OF ABNORMAL MILK SECRETED DURING OESTRUM.

NO.	SOLIDS	PROTEIN	FAT	SUGAR	ASH.
	%	%	%	%	%
1	9.21	2.57	.20	5.4	1.04
11	12.84	1.52	3.40	8.11	.81
15	13.23	2.85	3.50	6.33	.55
38	10.61	2.66	.45	7.05	.45
74	9.97	2.72	.13	6.57	.55
9A	13.93	3.23	4.40	5.86	.44
10A	12.42	3.23	5.30	3.15	.74

It would appear from the above figures that the same changes take place in mare's milk as in cow's milk during oestrum, the fat being the most variable constituent. No.1 of the Table had a remarkably high ash content (1.04 per cent), and when milk was drawn from the same mare ten days later it was/

was found that the ash had dropped to 0.64 per cent while the fat had increased from 0.20 to 0.38 per cent.

ABNORMAL FAT CONTENT.

Apart from variations during the oestral period, some abnormal percentages of fat were found; some being remarkably high and some very low. The following are the ten highest and the ten lowest percentages.

TABLE VIII.

ABNORMAL FAT PERCENTAGES.

NO.	PERIOD	HIGHEST %	NO.	PERIOD	LOWEST. %
72	58 hrs.	13.13	43	19 days	.09
78	3 days	12.47	74	7 days	.13
56	1 day	8.23	52	35 days	.20
9	10 days	7.88	1	10 days	.20
31	2 days	5.64	29	35 days	.25
10A	16 days	5.30	97	21 days	.26
9A	21 days	4.40	125	120 days	.28
22	36 hrs.	3.81	118	13 hrs.	.28
13A	---	3.60	84	---	.29
15	10 days	3.50	2	1 day	.30

ABNORMALLY/

ABNORMALLY HIGH FAT CONTENT.

In seven cases out of ten showing the highest percentage of fat, observations by the attendant veterinarian on the state of health of the foals suckled by the mares are available. Of the remaining three, two foals died at birth, concerning the other no record was obtainable.

The records given in TABLE VIII, taken in conjunction with the clinical history of the foals, are of sufficient importance to merit detailed consideration.

MARE No. 72. had had 2 foals, one in 1928 and one in 1929, both of which died when they were a day old. Her milk was analysed in 1929 on the day the foal was born and was found to contain 13.13 per cent of fat. Another sample was obtained four days later and the fat percentage had then dropped to 6.62. This milk was obviously too rich in fat.

MARE/

MARE No. 78. The milk of this animal contained 12.47 per cent of fat. The foal lived for three days and died from jaundice. The milk was obtained the day the foal died.

MARE No. 56. This was an abnormal colostrum milk containing 8.23 per cent of fat. The foal died during delivery and consequently the effect of this milk could not be noted.

MARE No. 9. The milk contained 7.88 per cent of fat. The mare had a foal in 1928 and another in 1929. Both of them died from malnutrition when a week old. The composition of the milk, which was free from colostrum when sampled, is abnormal generally as the following figures show:- total solids, 18.74%; protein 7.60%; fat, 7.88%; sugar 2.31%; ash 0.95%.

MARE No. 31. The milk contained 5.64 per cent of fat. The mare had had two foals (1928 and 1929) both of which died when two days old.

MARE/

MARE No. 10A. This mare was giving a large flow of milk and the foal had persistent diarrhoea. The milk was found to contain 5.30 per cent of fat and presumably was too rich for the foal.

MARE No. 9A. The milk contained 4.40 per cent of fat. The veterinary record of the mare, an aged hunter, is that she had had two foals, both of which appeared quite healthy at birth. The first (1928) died from malnutrition and the second (1929), at three weeks old, when the milk was sampled, was in an unthrifty condition, troubled with diarrhoea and not expected to live.

MARE No. 22. This was colostrum containing 3.81 per cent of fat. No record of the foal was available.

MARE No. 13A. The milk contained 3.6 per cent of fat. The foal died as the result of an accident.

MARE/

MARE No. 15. This milk containing 3.5 per cent of fat was obtained from a Clydesdale mare that had had two foals (1928; 1929) both of which throve well.

These records clearly support the contention that foals do not thrive on milk very rich in fat. In six of the ten instances when the mares were producing milk containing considerably more fat than the average, the foals failed to thrive; of the remaining four, two foals died from causes not associated with nutrition. Concerning one no record was obtainable, while in another, where the milk contained 3.5 per cent of fat, the mare was able to rear her foal satisfactorily.

On the other hand, during the course of this investigation evidence has been collected which shows that it is possible for foals to be well nourished when the fat is as high as 2.5 per cent, or, as in the instance of MARE No. 15, even as high as 3.5 per cent.

MILK/

MILK WITH LOW PERCENTAGE OF FAT.

While the foregoing analyses give support to the common belief that milk very rich in fat does not agree with young foals, the investigation has also shown that foals can thrive on milk containing considerably less than the average amount of fat. Of the ten lowest percentage detailed in TABLE VIII, with the exception of Nos. 84 & 2, there is no record of the foals doing badly, while on the other hand definite statements have been received from those sending the milk that the foals were doing well when the samples were taken. Of the two exceptions, No. 84, a Thoroughbred mare whose milk contained 0.29 per cent of fat, the sample was sent by a veterinary surgeon with the statement that the mare had been "a bad mother for several years". Milk from No. 2 (a Shire mare) containing 0.30 per cent of fat, was also sent by a veterinary surgeon with a request for information concerning the milk because the mare's previous foals had always done badly. In this case it is noted that particular care was taken to avoid the risk of obtaining "pressure" milk with a small amount of fat.

With these two exceptions, there would appear/

appear to be evidence from the 142 samples tested that foals can be successfully reared when the dam's milk contains less than 1 per cent of fat. The lowest percentages of fat which I have found previously recorded are 0.12 per cent by FLEISHMANN and 0.37 per cent by PATERSON and HÖFKER.

In view of the fact that the percentage of fat decreases with the increase of pressure within the udder, and that consequently the longer the animal is left unmilked the lower the percentage of fat, undue importance perhaps should not be attached to the low figures found in this investigation, notwithstanding the circumstance that every effort was made to obtain representative samples.

In order to determine the extent of the variability of the fat content when the milk is left in the udder for different periods, a Shetland pony mare with her foal a week old was obtained and housed in the College. The foal was kept from the mother for a lengthening time each morning, the udder being then emptied by hand and the fat percentage determined. TABLE IX gives the results of the analyses and shows how quickly, in the mare, cessation from suckling (or handmilking) causes fat depression.

TABLE IX.

VARIATIONS IN FAT IN AN INDIVIDUAL MARE.

PONY 87.

HOURS SEPARATED FROM FOAL.	FAT PERCENTAGE.
1½	1.10
2	.85
2	1.60
2	1.60
2	1.20
3	1.20
3	.70
4	.90
4	.90
4	.50
5	.40
5	.35

As previously said, the effect of stasis in the udder of cows is well known to lower the percentage of fat. This being so, it is reasonable to suppose that the same thing would occur in the mare under/

under similar conditions, and the above figures lend support to the supposition. They furthermore suggest the probability that some - but not all - of the records of low fat percentages in mares may be due to this cause. Clearly, the old established practice of "milking out" the mare when returning from work before allowing the foal to suck is sound.

One may assume that the optimum amount of fat in milk is that which lies nearest to the average, provided that this represents the mean of a number of analyses sufficiently large to give a reliable figure; and provided also that the composition of the milk has not been modified by artificial selection in breeding, as has been done with dairy cows. The average percentage of fat in mare's milk, computed from the mean of former records and the mean of milks analysed in this investigation, is 1.44 per cent.

Presumably the farther the fat percentage is from the mean or "normal" in either direction, the less likely is the milk to meet the requirements of the young. We have no knowledge either of minimum fat requirements for the foal, or of the maximum amount that can be partaken of without causing digestive and metabolic disturbance.

When/

When considering the nutritive value of milk for calves and lambs definite live-weight gains can easily be ascertained and utilised as indices of the body's response to available nutriment; but in the case of foals this is not practicable, and judgment on the suitability of the milk can only be formed by studying the young animal's appearance, condition and general health.

In many of the cases recorded above, reports on the condition of the foal have been supplied by breeders and veterinary surgeons when the milk samples were sent to the laboratory, and from these one is led to conclude that foals can thrive well on milk containing as little as 0.2 per cent of fat. On the other hand, milk containing 4 per cent of fat (or possibly less) does not appear to give satisfactory results. Mares secreting milk rich in fat are not therefore to be regarded as ideal for breeding. The old established custom of giving preference to cow's milk low in butter fat, or diluting the milk, when it is necessary to rear foals artificially, is therefore sound.

When studying the fat-content of ewe's milk and its relation to growth, RITZMAN (26) found great variation between individuals of the same breed, and also/

also in the milk of the same individual at different periods during lactation or during different lactation periods.* RITZMAN analysed 158 samples of ewe's milk and found a range of 2.4 to 12.1 per cent of fat and he expressed the view that fat is exceedingly variable in individual ewes regardless of breed or age. The present investigation has disclosed the same to be true of mares, where in 142 samples the range was from 0.09 to 13.13 per cent.

In discussing the results of his enquiry, RITZMAN points out that where the entire yield of milk is taken by the young, a variation in the fat-content can assume importance only inasmuch as it may be a determining factor in the rapid growth of the animal. He found that lambs consuming milk rich in fat did not thrive better than those getting milk poor in fat; in fact his figures seem to indicate the reverse; but, as he points out, the quantity of milk yielded by the mother seems after all to be the determining factor.

In short, the main function of milk fat is to stimulate growth and so long as that function is being fulfilled an excess of fat beyond the amount required for the purpose is not necessary but, on the contrary, may even be harmful.

LACTOSE/

---

* The same has also been noted in cows.

LACTOSE.

The percentage of lactose in mare's milk is fairly constant, the average falling between 6 and 7 per cent. It is often considerably less than this in colostrum, and after the colostral period has passed, percentages higher or lower than the average are possible. Only four out of 104 non-colostral samples analysed were found to contain 8 per cent or over of lactose. Greater divergence from the average was found in samples that contained less than the normal.

The following table gives the ten highest and the ten lowest percentages of sugar found in the samples examined.

TABLE X.

ABNORMAL LACTOSE QUANTITIES
(not including colostrum).

CASE NO.	HIGH.	CASE NO.	LOW.
	%		%
41	8.78	24A	1.65
98	8.29	9	2.31
34	8.17	88	3.06
112	8.07	59	3.13
84	7.85	76	3.82
43	7.50	8	3.93
39	7.48	4A	4.01
48	7.37	32	4.24
44	7.26	115	4.78
60	7.26	77	4.97

There/

There is no evidence in the history sheets of the foals that milk somewhat above the average in lactose is deleterious, provided that it is otherwise normal. On the contrary, two of the ten foals referred to in the table are reported "to be doing extremely well".

Milk containing less than 4 per cent of sugar, however, does not seem suitable, for the records show that the foals were unthrifty or had died of malnutrition.

It is interesting to observe that, among the ten lowest records of lactose, in only one instance (No. 9) was there an abnormally large fat-content.

THE/

THE MILK OF AGED MARES.

It is well-known that aged animals can successfully rear offspring, and analyses of the milk of old cows show that its composition is normal even up to the age of 23 years (27). But search has failed to discover records of the yield and composition of the milk of aged brood mares.

As a contribution to knowledge on this, and as part of the investigation now being discussed the/

the milk of 18 mares, aged ten years or more, has been examined. In no case was a sample taken during the colostral period. TABLE XI shows the result of analyses.

TABLE XI.

NO.	AGE IN YEARS.	SOLIDS	PROTEIN	FAT	SUGAR	ASH
		%	%	%	%	%
4	10	11.11	3.88	.31	6.17	.75
29	10	9.26	1.99	.25	6.73	.29
102	10	11.26	2.60	1.89	6.27	.50
19	12	11.47	2.80	1.68	6.42	.57
48	13	12.97	2.76	2.28	7.37	.56
85	13	10.83	2.65	1.58	6.01	.59
92	13	13.02	4.62	2.32	5.44	.64
45	14	11.43	3.23	.67	6.99	.54
15A	14	8.95	2.91	.40	5.19	.45
93	16	10.77	2.53	2.40	5.42	.42
70	17	12.97	6.26	2.01	1.91	.79
98	18	12.05	1.52	1.82	8.29	.42
20	18	12.26	2.42	3.35	6.09	.40
55	19	8.64	2.08	.35	5.78	.43
27	20	11.68	2.26	1.99	7.01	.42
124	24	12.12	3.29	2.14	6.09	.60
95	Aged	11.81	3.10	2.21	5.88	.62
9A	Aged	13.93	3.23	4.40	5.86	.44

A study of these figures reveals that aged mares, as in the case of aged cows, secrete milk that is not poor in quality; on the contrary, the milk has a tendency towards richness. Among these eighteen cases, however, there is a considerable degree of variation in all the constituents.

TABLE XII.

THE. COMPOSITION OF MARE'S COLOSTRUM.

NO.	BREED	AGE	HRS. AFTER FOALING	SOLIDS	PRO-TEIN	FAT	SUGAR	ASH
				%	%	%	%	%
47	S	3	1st.Milk	15.91	8.32	1.21	5.84	.54
57	T	7	1st.Milk	28.88	25.00	.63	2.41	.84
111	C	7	4	17.11	9.68	2.30	4.60	.53
91	C	6	6	16.91	10.95	1.60	3.64	.72
79	C	8	8	19.70	15.12	.41	3.50	.66
108	C	6	8	17.02	11.00	.93	4.32	.77
68	C	19	10	- -	13.67	1.60	-	-
5	H	9	12	15.34	4.75	3.32	6.69	.58
6	S	9	12	16.38	11.84	.22	3.61	.71
30	C	11	12	14.81	8.74	.42	5.11	.54
114	C	20	12	12.52	4.84	2.31	4.81	.56
117	?	?	13	12.25	6.39	.28	5.00	.58
82	C	7	14	11.42	4.30	.64	5.95	.53
65	C	Aged	16	13.17	5.68	1.80	5.07	.62
58	C	9	18	16.68	8.93	2.64	2.42	.69
2	S	?	24	15.60	8.19	.30	5.47	.64
56	T	6	24	19.73	?	8.23	?	1.06
64	R	?	24	12.40	3.35	2.70	5.75	.60
A20	?	?	24	10.87	4.68	.50	5.22	.47
A21	?	?	24	10.42	3.73	.80	5.42	.47
99	C	6	33	10.60	3.42	1.11	4.49	.58
22	S	?	36	19.07	12.15	3.81	2.40	.71
62	?	6	36	12.22	3.29	2.52	5.84	.57
23	C	13	48	11.39	2.51	1.94	6.54	.40
31	C	?	48	18.59	6.96	5.64	5.39	.60
61	C	15	48	12.35	3.84	2.20	5.75	.56
67	?	11	48	11.05	3.03	1.29	6.12	.61
75	S	4	48	13.04	7.91	1.74	2.67	.72
80	C	5	48	12.75	3.48	2.60	6.08	.59
94	C	5	48	14.71	?	3.29	?	.64
105	S	?	48	12.32	5.38	2.19	4.23	.52
72	C	7	60	26.61	8.61	13.13	4.10	.77
13	C	13	72	12.21	4.17	.35	6.04	.65
16	C	7	72	11.73	3.70	.51	6.78	.73
73	C	12	72	11.76	3.61	2.59	4.99	.57
A91	C	6	72	10.26	2.83	2.85	4.00	.58
104	C	3	72	9.47	4.81	.31	3.87	.48
78	C	16	72	24.09	9.43	12.47	1.46	.73

COLOSTRUM.

Since it is possible to obtain samples at any desired time after parturition, analyses of the cow have been made with some degree of completion. Unfortunately examination of mare's colostrum offers much greater difficulty because of the reluctance on the part of the owner to consent to the taking of samples at definite intervals of time. An attempt was made to overcome the difficulty and procure material for analysis at definite periods by the purchase of an in-foal pony. Unhappily the animal died before foaling.

Nevertheless a certain amount of information has been gathered from the analysis of the milk of thirty-eight mares taken at various times up to and including the third day after parturition. Colostral milk was received from Clydesdale, Shire, Thoroughbred and Hunter mares and the result of the analyses is given in TABLE XII.

These analyses show that mare's colostrum, so far as its composition has been studied, has the same characteristics as the colostral milk of other animals. It is much richer in mineral constituents, protein/

protein and total solids than normal milk and contains slightly less sugar. In regard to the percentage of fat, this enquiry has yielded results similar to those obtained in the analysis of cow's colostrum; fat may be normal or greater or less than the average. In four instances abnormally high percentages of fat were found:- 13.13 per cent; 12.47 per cent; 8.23 per cent; and 5.64 per cent; these have been discussed in connection with Abnormal Milks. One sample of colostrum, taken from the first milk drawn from a Thoroughbred mare (No. 57), was of a very viscid character and contained an unusually large quantity of protein (25 percent); the total solids being 28.88 per cent.

Judging from the samples examined, it seems clear that mare's milk is still definitely colostral in nature three days after parturition.

Other records of the analysis of mare's colostrum are scanty but CAMERER and SÖLDNER (28) give the results of three analyses as follows:-

	PROTEIN %	FAT %	SUGAR %	ASH %
1.	7.82	2.64	4.39	0.63
2.	8.37	1.77	4.24	0.67
3.	6.10	2.33	4.49	0.64

"WITCHES MILK" (HEXENMILCH).

Milk secreted by human infants and other immature mammals is commonly referred to as "Witches Milk" (Hexenmilch) and has been the subject of frequent comment in the professional journals. In 1847 JOHN COVENTRY, Surgeon, in a letter to the Lancet (29) records the case of a female infant three weeks old with mammary glands the size of a walnut from which there issued a continuous oozing of milk. In the same periodical (30) in 1867, was published a considerable correspondence from medical practitioners who gave instances of the secretion of what appeared to be normal milk from the mammary glands of both male and female children at birth or during the first few days after birth. In none of these early cases was the fluid analysed.

As examples of the occurrence of "Witches Milk" in the lower mammals may be quoted those reported by AMMON and DAYOT. AMMON (31) records the mammary secretion in a five-weeks-old foal and states that it contained, casein, 0.5%; albumin 1.02%; extractives and sugar, 3.67%, and ash 0,44%. DAYOT (32) relates his experience of a colt, eleven days/

days old, which "could be milked like a cow".

As it chanced, during the course of this investigation, two instances of foals secreting milk at birth were reported, and the milk was sent for analysis.

CASE NO. 1. During the foaling season of 1928 Mr R.N. Lewis, M.R.C.V.S. of Campbletown, forwarded to me milk-like fluid from a filly foal of a Clydesdale mare. The foal, when two days old, had a swollen and painful mammary gland from which about half a pint of milk was withdrawn by handmilking. This and a sample of milk from the mother were analysed and found to have the following composition (33) :-

	SOLIDS %	PROTEIN %	FAT %	SUGAR %	ASH %
Mother	11.43	3.23	0.67	6.99	0.54
Foal	8.64	2.96	0.10	5.21	0.37

In contradistinction to Case No. 2, all the previous foals, seven in number, born of this mare were normal.

CASE/

CASE NO. 2. In 1929 I received a sample of milk from a foal four days old, the dam of which had a different record. She was a cart mare, and had had three foals. The first foal had a cleft palate and supernumerary digits; the second, born in 1928 died shortly after birth; the present, (third) foal was born with a remarkably thick umbilical cord and abnormal mammary glands, about the size of a large tea-cup and very hard. The composition of the milk from the foal and the dam was as follows:-

	TOTAL SOLIDS %	PROTEIN %	FAT %	SUGAR %	ASH %
Mother	10.27	2.72	1.30	5.71	0.54
Foal	10.18	1.76	2.12	5.91	0.39

Four days later, when the foal was eight days old, a further sample was obtained and the total protein was separated out to its casein, globulin and albumin constituents. This sample was found to contain 3.58 per cent of protein made up of casein, 2.03/

2.03 per cent; globulin, 0.86 per cent; and albumin 0.69 per cent. The higher percentage of protein in the later sample is probably accounted for by concentration in the udder owing to turgescence resulting from incomplete milking, and the relatively large amount of globulin seems to suggest that the milk was of a colostral nature. Nevertheless, in view of the well-known difficulty of accurately determining the relative proportions of the milk-protein constituents - a difficulty that is even greater with mare's milk than with cow's milk - these figures are stated with some degree of diffidence.

In view of the fact that, apparently, no analyses have been made of the ash of foal's milk, a portion (20 grammes) of the second sample was utilised for this purpose, and was found to contain 0.58 per cent of ash, an increase over that obtained (0.39 per cent) in the first sample. Of mineral constituents it was only possible to determine the percentages of chlorine, calcium, magnesium and phosphorus in this sample; and, unfortunately, no further/

further supplies were obtainable. The ash was found to contain:- chlorine, 0.230 per cent; calcium oxide, 0.041 per cent; magnesium oxide 0.014 per cent; and phosphoric anhydride 0.079 per cent. The chlorine quantity is considerably greater than that found in normal mare's milk, while the calcium is less than the normal and the magnesium and phosphorus are approximately the same.

The foregoing analyses clearly suggest that the mammary secretion of the new-born is truly milk; it has, however, not yet been determined if so-called "Witches Milk" is chemically and physically normal milk or to what extent it has the characteristics of colostrum. As already stated, the amount of globulin found in one of the samples is greater than that found in normal milk and is therefore suggestive of colostrum. To those interested in the study of the causation of milk secretion the production of such milk should be of particular interest.

Numerous cases have also been placed on record of adult animals secreting milk at abnormal periods. For example, MONVOISIN (34) refers to abnormal secretion in a mare, a sow, a mule and a heifer, and discusses the well-known and common occurrence of bitches secreting milk after a period of sexual activity. He gives WEDEMEYER'S analysis of such milk from a ten months' old bitch as follows/

follows:- total solids, 31.91 per cent; protein 10.18 per cent; fat, 15.54 per cent; sugar, 3.71 per cent; and ash, 1.10 per cent. This is somewhat richer in protein, fat and total solids than normal bitch's milk, but supports the contention - disputed by some - that the fluid secreted under these circumstances has the characteristics of normal milk.

GRIMMER (35) refers to what he calls "Witches Milk" at some length, pointing out its somewhat frequent occurrence and giving numerous references to published papers. Among these special attention is directed to an early record by DUJES (36) who analysed the milk secreted by a mule and found its composition to be:- protein, 1.95 per cent; fat 1.7 per cent; sugar, 5.13 per cent; and ash, 0.38 per cent; from which it is clear that the fluid secreted by this particular lactating mule had the same composition as normal mare's milk.

SUMMARY/

SUMMARY.

I. Samples of milk from one-hundred-and-forty-two mares have been analysed for the purpose of determining the percentage of solids, protein, fat, lactose and ash.

II. Of this number, thirty-eight samples were taken during the period of colostrum secretion and one hundred and four were colostrum-free milks.

III. The average composition of the milk of British mares has been found to be in close agreement with that of Continental mares. The only marked difference is in the percentage of ash.

IV. The average percentage of ash in the milk of Continental mares is 0.38 and in the milk of British mares 0.51. It has been found that in the lighter British breeds (Ponies and Thoroughbreds) the ash content is similar to that of the Continental/

continental mares, whereas in the heavier breeds (Clydesdales and Shires) the percentage of ash is appreciably greater.

V. With the exception of the mineral content, there are no marked differences between the milks of the various British breeds.

VI. Included in the samples examined were some from mares whose foals were not thriving; some of these milks were found to be abnormal.

VII. The occurrence of oestrum in the mare commonly causes nutritional disturbance in the sucking foal.

VIII. Milk with a high percentage of fat is unsuitable for foals, and mares that secrete milk of this nature do not rear their foals satisfactorily.

IX/

IX. On the other hand, foals appear to thrive well if the milk contains very little fat.

X. The percentage of lactose in mare's milk is fairly constant. When divergence from the normal occurs, a slight excess does not appear to be harmful. Foals do not thrive when the milk contains much less lactose than is normally present.

XI. Aged mares secrete milk that is normal or with a tendency towards richness.

XII. The colostrum of mares has the same characteristics as the colostrum of cows.

XIII. Two samples of "Witches Milk" (Hexenmilch) obtained from fillies born with fully functioning udders were analysed and in each case the milk was found to have practically the same composition as normal milk.

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